

REMARKS

Claims 1-18 are pending. Claims 1 and 9 have been amended to recite that the annular pattern is ring shaped. Also, new claims 17 and 18 recite that the ring shape is not fully circular. Support for these features can be found in paragraph 0042 and Fig. 2A, 2B, 2C, 3A and 3B.

No new matter has been added by way of the above-amendment.

Issues under 35 U.S.C. § 103

Claims 1-2, 7, 9-10, and 15 are rejected under 35 U.S.C. 103(a) as being unpatentable over Collet-Beillon (US 5,574,801) in view of Sepai et al. (US 5,455,870, referred to as "Sepai" herein) and further in view of Wagner et al. (paper titled "Evaluation of three template matching algorithms for registering images of the eye", referred to as "Wagner" herein). Applicants respectfully traverse the rejection.

Advantages of the present invention:

The present invention relates to a method and apparatus for inspecting a bump electrode including a micro solder ball (hereinafter referred to as a ball) used as a bump electrode of a semiconductor element such as an LSI. In practice, the deformation of a ball, a missing ball or an incorrect ball size are different kinds of defects to be inspected. Since an incorrect size ball can cause an improper connection at mounting, it is important to determine the size of the ball as well as other items to be inspected. If the presence of a small ball is to be determined by using pattern matching based on a single template image, the determination is more difficult compared to the determination of a missing ball because a luminance distribution of an acceptable product and that of a small ball are fairly the same. In addition, averaging a large number of images of acceptable products using a template image is a very time-consuming process.

The inventive process and apparatus can analyze for defects in a time efficient manner with high accuracy. In the inventive process, the bump electrode is inspected in the following steps: illuminating a substrate in an oblique direction where balls are arrayed by using an annular type illumination device to form a ring-shaped annular pattern; photographing the substrate from above the substrate; correcting a gradation of the photographed image of the annular pattern by

using a function with a saturation characteristic; making a segmented image which includes an image corresponding to at least one ball; and determining whether each bump electrode is an acceptable product or not by pattern matching by calculating a normalized correlation coefficient between the segmented image and a template image prepared in advance. The inventive process and apparatus are far superior to that which is known in the art.

Patentable distinctions between the present invention and the teachings of the cited art:

In order to further distinguish the present invention from the teachings of Collet-Beillon, Sepai et al. and Wagner, Applicants have amended claims 1 and 9 to recite that the shape of the reflected light is "ring-shaped."

The reference the Examiner is relying upon for teaching the reflected light is Collet-Beillon. The Examiner will note that the shape of the signal (reflected light) is determined by the direction in which the light is used to illuminate the balls. The illuminating light used in Figs. 8 and 9 (shown below for the Examiner's convenience) of Collet-Beillon gives a "crescent moon" shaped reflection because the illuminating light proceeds from an obtuse angle from a single source.

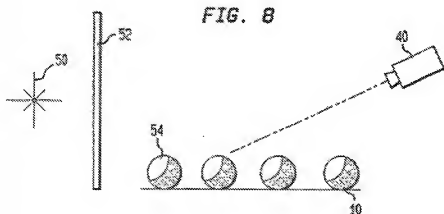
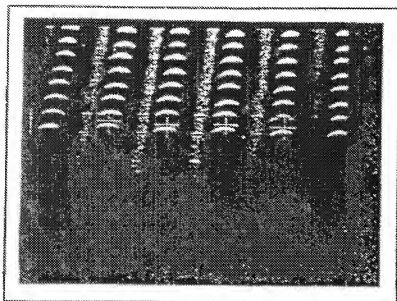


FIG. 9



This is in distinction to the inventive method and apparatus, wherein the illuminating light gives a "doughnut" or "ring shaped" reflection because the illuminating light proceeds from an obtuse angle from at least two sources. This is shown in the nonlimiting embodiment of instant Fig. 2A and 2B which are reproduced below for the Examiner's convenience.

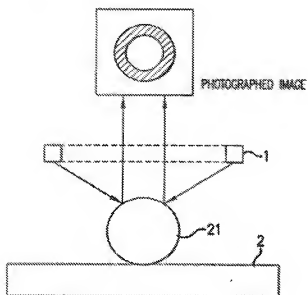


FIG.2A

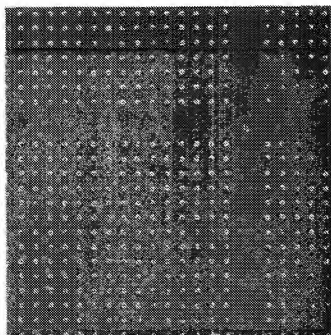


FIG.2B

As the Examiner will note from the instant specification, the calculations used by the present inventors for analyzing this data (the ring-shaped reflection), take into consideration the thickness of the ring-shaped annular pattern as well as the radius/diameter of the rings, see e.g., Fig. 3A of the present specification which is now reproduced for the Examiner's convenience.

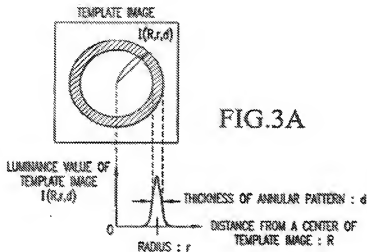


FIG.3A

As the MPEP directs, all the claim limitations must be taught or suggested by the prior art to establish a *prima facie* case of obviousness. See MPEP § 2143.03. In view of the fact that none of Collet-Beillon, Sepai et al. and Wagner, teach or fairly suggest modifying the apparatus to give a ring shaped annular pattern, a *prima facie* case of obviousness cannot be said to exist. Accordingly, withdrawal of the rejection is respectfully requested.

In view of the above amendment, applicant believes the pending application is in condition for allowance.

Conclusion

In view of the above remarks, it is believed that claims are allowable.


Should there be any outstanding matters that need to be resolved in the present application, the Examiner is respectfully requested to contact Garth M. Dahlen, Ph.D., Esq., Reg.

No. 43,575 at the telephone number of the undersigned below, to conduct an interview in an effort to expedite prosecution in connection with the present application.

If necessary, the Commissioner is hereby authorized in this, concurrent, and future replies to charge payment or credit any overpayment to Deposit Account No. 02-2448 for any additional fees required under 37.C.F.R. §§1.16 or 1.14; particularly, extension of time fees.

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Respectfully submitted,

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